BURBANK FIELD, OSAGE COUNTY, OKLAHOMA

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The purpose of this paper is to direct attention to: (1) the importance of the study of sand conditions of any field and the effect of such conditions on the concentration and production of oil, and (2) the probability that rapid development of a field with subsequent open flow from the wells where the producing sand is close-grained produces a much larger ultimate production.

GENERAL GEOLOGY

The geology of the Burbank field has been so well covered in another publication[1] that time will not be taken here to go into this subject in detail.

Osage County is in the northeastern part of Oklahoma. All of the county is underlain by rocks of Pennsylvanian age, which are covered in the northwestern corner by Permian beds. The Pennsylvanian series is composed of interstratified limestone, sandstone, and shale with the sandstone and shale predominating. The general dip of the strata is about 30 feet to the mile a little north of west. The most important oil-bearing horizon of the Pennsylvanian in the county is the Bartlesville sand, which is near the base of the series. It varies in thickness from 30 to 100 feet. In eastern Osage County and Washington County this sand is fairly coarse, porous, and siliceous, but to the west it becomes finer-grained and more calcareous until, on reaching a line running in a northeast and southwest direction almost through the center of the county, it thins and disappears. This led to a lack of faith upon the part of oil men and geologists as to oil possibilities in the northwestern portion of Osage County. It had been known for some time that large structures were located there, but as some of these had been

[1] *U. S. Geol. Survey Bull. 686.*

drilled with unsatisfactory results, no one was interested in that vicinity until the Carter Oil Company developed production in the NE. of Sec. 9, T. 26 N., R. 6 E., in September, 1920, and the Marland Oil Company in the S.E. of Sec. 36, T. 27 N., R. 5 E., in May, 1920. From that time on, at each successive Osage sale, prices for acreage in this field have increased until in September, 1922, $1,600,000, or $10,000 per acre, was paid for 160 acres in the southeast quarter of Sec. 24, T. 27 N., R. 5 E., and many quarter-sections have sold for over $1,000,000 each.

STRUCTURAL CONDITIONS

Figure 1 shows structural conditions apparent on the surface, using the Stonebraker limestone as a datum. Figure 2, a structure map using the top of the producing horizon as a datum, demonstrates the conformity of the surface and subsurface strata, although, as usual in Osage County, the reversal on the east side and dips on the west side of the folds are greater on the producing sand than at the surface. These structure maps show the highest point of the Burbank fold in Sec. 9, T. 26 N., R. 6 E., with a reversal or dips to the east and south of about 30 feet in each direction. On the western flank of the fold where Townships 26 and 27 and Ranges 5 and 6 meet, is a lesser dome with about 20 feet reversal. A study of Figure 2 will show several other small domes farther north and west. The structure, then, might be classed as a plunging anticline with the major axis running northwest and southeast and its highest point near its southeastern extremity.

PRODUCING SAND

While the Burbank sand does not seem to be connected with the Bartlesville sand, it appears to occur in the same stratigraphic position. As far as we have been able to ascertain, the sand of this field is a delta deposit. A small amount of this sand is present at the southern end of the Mervine field, 10 miles west, in Kay County, and it appears to be continuous with the Burbank sand. There are a few other small local sand bodies in the western Osage which correlate with the Burbank sand but do not seem to be connected with it. Therefore, while the Bartlesville sand was apparently deposited from a land mass to the east, this sand has probably been deposited in the same sea and at the same time, but was derived from a land mass to the west. While there may be several such deposits, the sand in the Burbank field is probably the largest and most productive of these.

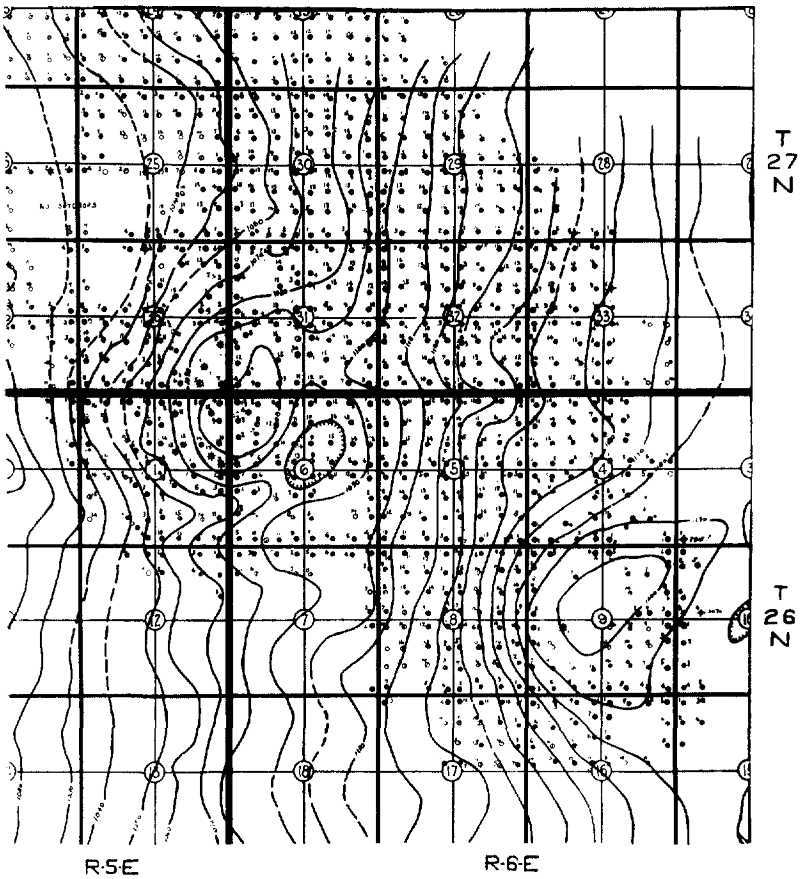

FIG. 1

The thickness of the producing horizon varies from 50 feet to 80 feet. It is a fine-grained, calcareous sand interstratified, to a small extent, with thin beds of blue or brown shale. It is probable that this whole thickness is not productive. Most wells show increased production at several different points in drilling through the sand.

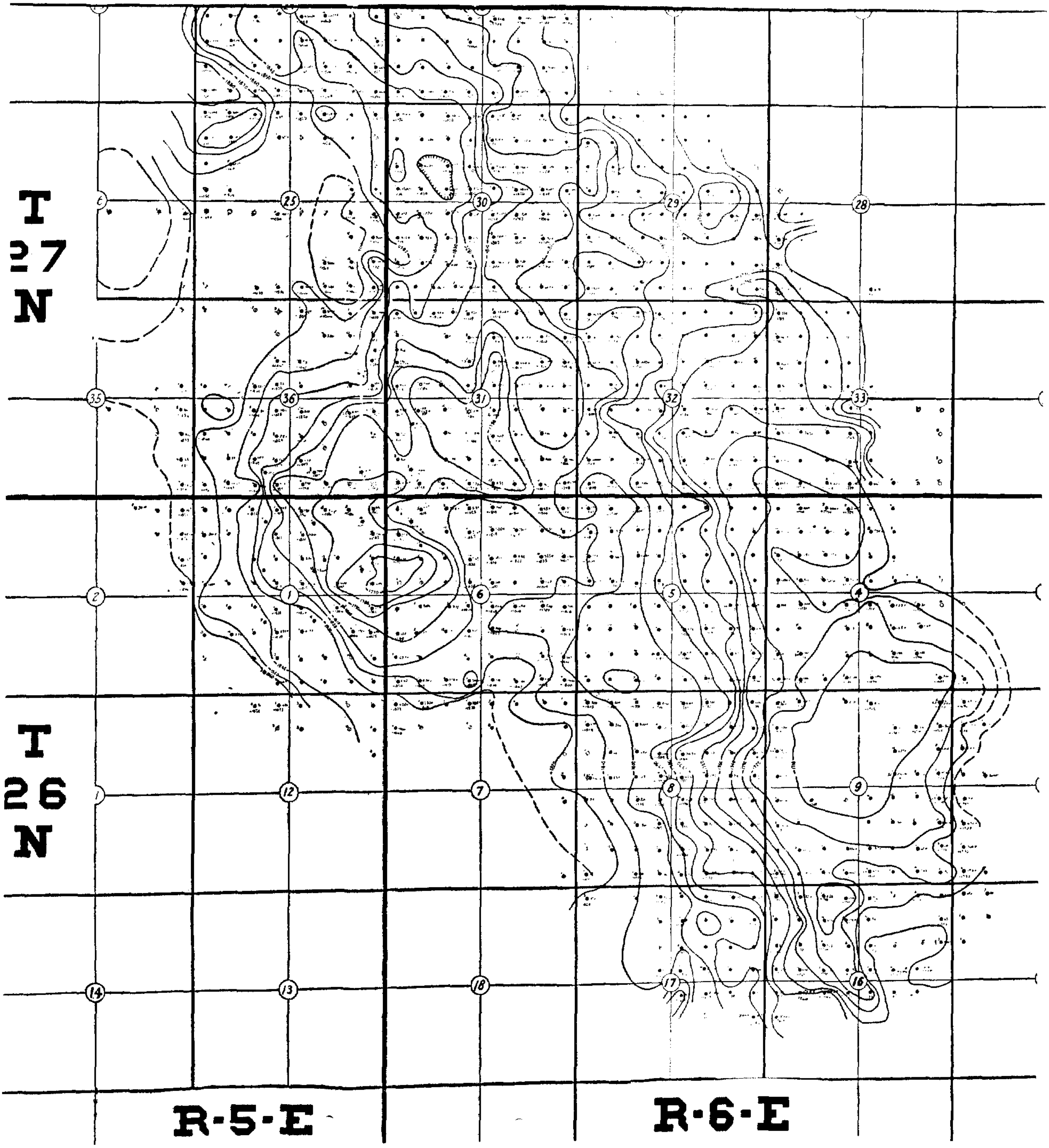

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FIG. 2

From the best information obtainable it seems probable that from 25 to 40 feet of this sand is productive, this thickness being divided into three or four zones. Producing wells have an initial yield of 50 to 8,000 barrels per day, accompanied by considerable gas. In many of the wells a pure gas sand, 10 to 30 feet in thickness, is found on top of the oil sand. In some wells a 3-foot break of blue shale separates this gas sand from the oil. Production, then, in this field seems to be confined on the north and east sides by a gradation of the sand to an impervious shale, while on the south and west sides it is confined by salt water as the normal dip is continued to the west.

PRODUCTION

The production of the Burbank field to December 31, 1923, was 61,923,485 barrels from 1,110 wells on 120 quarter-sections.

TABLE I

Section	Date First Well Drilled In	Total Production to Dec. 31, 1923	No. Wells Completed to Dec. 31, 1923	Production per Acre	Length of Time Producing	Subsea Elevation Top of Sand
		Bbl.		Bbl.	Months	
1. 9-26-6	Sept., 1920	2,234,698	44	3,500	40	−1,710′
2. NE. 1-26-5, NW. 6-26-6, SW. 31-27-6, SE. 36-27-5	Dec., 1920	2,261,320	63	3,500	37	−1,780′
3. 30-27-6	Aug., 1921	2,996,053	64	4,700	28	−1,800′−−1,840′
4. S.½ 24-27-5	Oct., 1922	3,591,482	32	11,500	15	−1,820′−−1,880′
5. NW.¼ 24-27-5	Apr., 1923	2,075,320	13	13,000	8	−1,820′−−1,880′

To bring out the fact that some agency other than structural conditions is responsible for the relative concentration of oil in the different parts of this field, five different groups of leases have been selected: (1) located on the highest point of the structure; (2) located on the second highest point of the structure; (3) one of the most centrally located and best producing sections in this part of the field; (4) and (5) the most productive portions of the field to date, 170 feet structurally below and 3 miles from the highest point.

A pertinent question, then, is: Why is the best production located 3 miles from the top of the structure and well down toward its lower end? It seems probable that the fine-grained character of the sand is largely responsible for this.

First development took place on the two highest parts of the structure, gradually moving north and west. Lessening of gas pressure on one lease has had very little influence on the gas pressure of a lease a half-mile away, and as the territory was developed farther north, wells a half-mile from older production came in with the same gas pressure, as would have been expected had no drainage taken place. It is also true that the higher portions of the anticline contain the largest proportion of gas, although the oil seems to be intimately mixed with sufficient gas at high pressure, even at the lowest points yet developed, to cause the wells to flow violently. Therefore, it would seem that gas, oil, and salt water accumulated in their respective places according to laws postulated in connection with the anticlinal theory, but, because of the fine-grained nature of the sand, did not migrate much from one lease to another after development started, but were largely produced from their original positions. As the sand on the lower portions of the fold had the largest oil content, these leases are most productive. When studying a new field it should, therefore, be kept in mind that sand conditions are often more important than structural conditions in locating the most productive portion of the pool. This is very important where prices are as high as has become so frequently the case in fields developed within the last few years.

Another cause which has helped to make the northwestern portion of the Burbank field so much more productive than the southern portion has been the rapidity with which the quarter-sections have been developed. In the southern portion, some quarter-sections are not yet fully developed, and many had an interval of fifteen months between the finishing of the first and the last wells. The northwest quarter of Sec. 24, T. 27 N., R. 5 E., owned by the Gypsy Oil Company, is the most productive lease so far developed. Thirteen wells were drilled on this tract before the shut-down agreement in this field took effect. There was less than two months between the finishing of the first and last of these wells which came in at from 1,600 to 3,600 barrels daily. This was the most rapid development in the field. The three remaining wells were brought in eight months later, producing only 60 to 900 barrels daily. Quarter-sections on either side of this one which were developed more slowly have not produced much more than half as much oil. The south half of Sec. 24, T. 27 N., R. 4 E. is the next most productive portion of the field and was also the next most rapid in development. Four months elapsed between the completion of the first and last wells. It was quite noticeable that gas pressure in many of these wells lessened more rapidly than oil production. The quick development allowed the greatest advantage to be taken of this gas pressure before it was dissipated, with a consequent large production of oil. This seems to bring out clearly the advisability of rapid development of an oil field where the producing sand is compact and fine-grained.

To bring this out more clearly, another example is given. The drilling of wells in 52 locations in this field was delayed over 90 days behind other wells finished on the same leases. The average production of these other wells was 300 barrels daily each. Therefore, if these 52 wells had been drilled in we might have expected them to produce 15,600 barrels per day in all. From the general decline in this vicinity it is figured that the production of these wells will be less than 200 barrels each at the end of the 90-day period. This, then, shows a loss of 1,115,000 barrels of production, caused by delay in drilling these wells in, which, at $2.00 per barrel, means a $2,230,000 loss. While granting that the decline in production of these leases as a whole might have been slightly more had all of these wells been drilled in without delay, yet the history of the field has shown that the decline in production where all of the wells on a lease are completed is by no means sufficient to make up the loss of flush production obtained when the gas pressure is in its original high state. In fact, settled wells in this field, as a whole, obey the law of equal decline from the same-sized wells, regardless of age. High ultimate production, then, can only be obtained where flush production under high gas pressure is large.

Gester, Gester, and Wagy, in their article entitled "More Oil through Closer-Spaced Wells," state in part:

> Gas is one of the principal motive forces which propels or carries the oil through the sands into a well and causes the well to flow or gush. Moreover,

gas is one of the important factors governing the accumulation or concentration of the oil into commercially productive fields. At depths found in the oil fields the gas is frequently under heavy pressure. When this pressure is released by the drilling of a well the gas moves toward the outlet, carrying oil with it. Because of its much greater mobility, the gas moves more rapidly than the oil and there is an opportunity, as the pressure is released, for some of the gas to become dissociated from the oil and for the oil to lag behind the gas in its movement toward the well.

This is exactly what seems to happen in the Burbank field and after the initial gas pressure has been largely dissipated, it is questionable if any but a very small area around each well can be drained of a reasonable proportion of the original oil content.

This can be reasoned out in a different manner: It takes a certain amount of pressure to drive oil a certain distance through the sand to a well. The finer-grained the sand and the greater viscosity possessed by the oil, the more pressure is required to drive the oil from the sand to the well. In Burbank the original pressure in many portions of the field was 800 pounds to the square inch. It is conceivable, therefore, that with the drilling of the wells there, at one well to 10 acres, it takes 800 pounds to drive some of the oil from portions between these wells to the well. As stated above, however, gas travels much more easily through the sand than oil and, therefore, less pressure is required to drive it to the well. This allows one or two wells on a quarter-section to dissipate the pressure on a whole lease within a few months so that wells completed later find a gas pressure of only 100 to 200 pounds per square inch. From the smaller production of these wells it would seem that this pressure is only sufficient to drive to the well the oil that is in close proximity, leaving a large proportion of the original content in place between the wells. Therefore, as shown in the foregoing production table, production from wells where the development has been slow and the gas pressure dissipated is very much less than where the lease is developed rapidly and the original gas pressure utilized to bring all the oil possible to the well. This statement is also agreed to by Cutler and Clute in their article on "Recoveries in Oklahoma Fields," and by Swigert and Schwarzenbek in their report on the "Hewitt Field of Oklahoma," where in two different instances from 53 to 73 per cent of the ultimate production was lost on account of delayed drilling. This, therefore, is not a new subject, but it is one of the most important ones facing the oil engineer or geologist today. At present we seem to be faced with an ever increasing consumption which must be supplied, and if petroleum engineers or geologists can increase production from new fields by 25 to 50 per cent of the flush production, with practically no additional cost to the producer, they will be doing a very great service, not only to their own companies but to the consuming public as well.

From the many fields which the writer has examined, it appears that it should be possible to work out definite data in this connection, the factors to be considered being gas pressure, viscosity of the oil, and the porosity and nature of the sand. Where the sand is very porous and the oil is mobile—enough so that the oil and gas would move with almost equal ease through the sand to the well—dissipation of the gas pressure without a corresponding production of oil would not take place. But where the sand is fine and close-grained and where the oil is heavy and viscous, the gas would travel through the sand much more rapidly than the oil and be uselessly dissipated. It, therefore, should be possible to ascertain what might be called the coefficient of resistance of any sand. By taking cores of the sand from several holes in any field, the oil content, porosity, composition, and other characteristics of the sand could be determined. These results, coupled with the viscosity of the oil and the rate of decline of gas pressure, should, with other refinements developed, give a scientific method of figuring out the most economic and profitable manner in which to develop new oil fields.

The writer suggests that such a movement be started by all members of this Association who are interested and who have the facilities to prosecute the investigation. The successful conclusion of such a course would advance this Association another big step in the esteem and confidence it has won with practical oil men and executives.